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ABSTRACT

Described in this manual are two field investigations which utilize the natural environment to teach ecological principles to high school students. In groups of five to ten, students study two aquatic environments and then prepare a booklet which summarizes their work. The manual is divided into four parts: (1) teacher's guide; (2) student's guide; (3) rivers, lakes, and ponds; and (4) sandy beaches. The teacher's guide describes goals and objectives, prerequisite student knowledge and skills, and stages of group growth. An overview of basic ecological principles and a discussion of the field study goals comprise the student's guide. The remaining two parts provide instructions for investigating a freshwater and a marine ecosystem. These activities consist primarily of transect and quadrat studies, chemical analysis, and species identification. Included in the appendix are some field procedures and a list of references. (WB)

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PATTERNS

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PATTERNS OF LIFE IN THE WATER

**Student Field Studies of Two of
Franklin County's Aquatic Ecosystems**

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an Environmental Education project entitled:
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For Franklin County Students**

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PART ONE
TEACHER'S GUIDE

I. INTRODUCTION

The purpose of the Patterns project is the utilization of the unique natural environment of Franklin County, Florida, to teach important ecological principles to high school students. The rationale behind this particular set of materials is simply that "the clearer and more immediate a student's view of his local biome, the clearer will be his understanding of other biomes."¹ Patterns of Life in the Water is a field-lab activity package through which the student learns first-hand about two aquatic ecosystems: one fresh-water, "Rivers, Lakes, and Ponds", and one marine, "Sandy Beaches". Both of these studies are designed for groups of students, and, in that context, contain activities centered around actual field experience, research, and laboratory experimentation. They attempt to guide the student through an in-depth study of his/her immediate natural environment. "Rivers, Lakes, and Ponds" is based upon trip(s) to either Carrabelle River or one of the numerous pond in the area of Carrabelle High School; and "Sandy Beaches" is keyed to a trip to one of Franklin County's beaches.

Both studies in the Patterns project relate to the same objectives, and therefore, may be used concurrently by two or more different groups in the same classroom. In this way, each student plays a more vital and unique role in completing the study, and all students benefit from knowledge gained by each group. The logical conclusion to the Patterns unit which has been organized in this multi-group fashion is a seminar-type discussion of results or even informal oral presentations by each group - a info-exchange. On the other hand, each of the studies is versatile enough to be incorporated into a variety of classroom situations.

The successful completion of the research aspect of the package necessitates the accessibility

of a fairly extensive collection of scientific resources, including field guides, lab guides, identification keys, pamphlets, government publications, textbooks, scientific journals, encyclopedias, and audio-visual aids. It is suggested that before beginning the unit, the teacher check the school media center to get an idea of the extent of available resources. Then the reference list included in this package can be amended, if necessary. Most of these books can be obtained through the school media specialist with an interlibrary loan.

Neither of the studies can be completed without at least one field trip to the study site. These are field-lab activities.

II. GOALS

1. "An understanding of the diversity of life and of the interrelations of all organisms in the complex web of life." ²
2. "An understanding of man's own place in nature: namely, that he is a living organism, that he has much in common with other organisms, and that he interacts with all organisms in the biological system of earth." ³
3. An understanding of the complex interweaving of the biotic and abiotic environments constituting an ecosystem.
4. An understanding of the necessity for a classification system for all organisms based on similarities and differences.
5. An understanding that in "any given region the naturally occurring organisms are those that can survive and successfully reproduce under the environmental conditions prevailing there." ⁴
6. An understanding of man's relationship with and potential impact upon various parameters of his environment and subsequently his environment as a whole.
7. An increased awareness of the diversity of attitudes and values towards the environment.⁵
8. A heightened awareness of and interest in the environment.
9. An understanding of the processes of scientific work: constructing hypotheses, choosing and using proper measurement tools, controlling variables, recording data, and drawing valid conclusions.
10. An acceptance of science as an "open-ended intellectual activity" and the development of an inquisitive attitude towards science.

III. OBJECTIVES

In addition to the above goals, the package identifies the following objectives. This is in accordance with one of the secondary purposes of the Patterns project, which was to provide for those teachers and students using BSCS-Green Version⁶ an alternative to Chapter Nine, entitled "Life in the Water". This module has been designed to replace or supplement that chapter and, at the same time, meet objectives compatible with those identified by the BSCS writers. After participating in a unit covering the two Patterns field-lab studies, the student will be able to:

1. distinguish between inland and ocean waters.
2. name at least four kinds of aquatic ecosystems.
3. describe in detail the characteristic abiotic factors in at least one of the ecosystems named, and compare them with those of at least one other type of aquatic ecosystem.
4. list a number of organisms characteristic of the ecosystems named.
5. demonstrate and explain the importance of a method for estimating the dissolved oxygen content of water.
6. demonstrate and describe a method for sampling a biotic community.
7. demonstrate or describe the quadrat, transect, or equally acceptable means of obtaining an accurate quantitative and qualitative description of an ecosystem.
8. explain how zonation occurs.
9. demonstrate at least three different analyses for soil samples.
10. demonstrate familiarity with classification by properly making and using a dichotomous key to organisms found in an ecosystem.

11. draw and label one possible food web found in an aquatic ecosystem.
12. describe at least three major ways in which man has physically changed aquatic ecosystems.
13. describe at least three ecological problems involving aquatic ecosystems which man must face.
14. list and describe five appropriate devices for collecting or analyzing specimens or measuring physical factors of aquatic ecosystems.

IV. PREREQUISITE STUDENT KNOWLEDGE AND SKILLS

It is recommended that before beginning work on any portion of this Patterns package, the student should:

1. have experience in the use of the compound microscope and the dissecting microscope.
2. know the proper way to make a wet mount.
3. have experience observing and recording data.
4. know how to make and use a dichotomous key.
5. have some experience working independently and in assuming responsibility for learning in the science classroom.
6. understand the significance and meaning of scientific names for biota.
7. be able to use a balance to determine the mass of an object.
8. understand the flow of energy through a food web, and be able to identify producer, first- and second-order consumers, and decomposers in that food web. (However, this is not crucial.)

V. STAGES OF GROUP GROWTH

(From Michael Giametto, Ph.D., quoted in Youthbook Conservation Corps Sourcebook for Environmental Awareness, People and Natural Resources (Summer, 1977), p.37-38.)

Every group has to spend time and energy learning how to work together. Usually some feelings develop among members while they are learning.

It takes time for group members, each different, to learn how each can fit into the group and contribute best. So things often seem "all mixed up," and group members may quite naturally become disturbed and discouraged - even aggravated with each other.

It helps to know that these are natural "growing pains" of democratic groups, that these feelings among members tend to follow predictable cycles or sequences, and that in most cases the group will soon become productive and efficient as people work to solve group problems.

Let's take a look at these stages in this developmental process.

1. "Groping": When the group is first finding out how to plan and work together they may not all agree. They don't know and understand each other well enough to really trust the group, and they still have to determine each others' skills, knowledge, situation, and attitudes. So they often feel uncomfortable and lost.

2. "Gripping": The group gets discouraged when they can't seem to work together, when there isn't much progress, and their attempts are frustrated.

They say wrong things to each other, play negative roles and block group action because they are uncomfortable. This is the place for more "self-other" understanding, to remember that they are all different but they all want to do a good job and be liked by others. Maybe they can learn to understand why others are griping, and learn to give themselves time to work things out.

3. "Grasping": Now ideas and suggestions are beginning to fit. The group begins to agree on questions, and can start to see some direction to group activity. Everyone begins to feel more comfortable and now they are getting somewhere.

4. "Grouping": They are really getting to know each other, and can understand and enjoy how each one works and fits into the tasks to be done. Group tasks, building, and maintenance roles come into play, and a surge of enthusiasm spreads through the group.

5. "Group Action": Now the group is in full swing, with members playing constructive roles, leadership shared, everyone participating. It was difficult at first, but worth it to learn to work will together, and feel this is a good group with which to work. They are busy making their group more democratic.

Now they are ready to tackle other jobs. It can be expected they will still go through some of these early stages, but each time it can be less disturbing, more effective.

So it is important to recognize how they feel about others in the group, to know that these feelings are natural whenever they really tackle important

jobs, to realize that the group can move ahead toward better feeling relations among members. As they get to know each other better, this group becomes their group because they have shared plans and work, and have tried to practice ways of behaving which are cooperative, considerate, friendly, democratic.

VI. SELECTED BIBLIOGRAPHY

- Andrews, W. A., ed. A Guide to Terrestrial Ecology. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1974.
- Berger, Neal H. "Environmental Management Study Area". Florida Department of Education, Office of Environmental Education Minigrant, 1974-75.
- Biological Sciences Curriculum Study. Biological Science: An Environmental Approach (Green Version). 3rd ed. New York: Rand-McNally Company, 1973.
- Brandwein, Paul; Joseph, Alexander; and Morholt, Evelyn. A Sourcebook for the Biological Sciences. New York: Harcourt, Brace, & World, Inc., 1966.
- Cox, George W. Laboratory Manual for General Ecology. Dubuque, Iowa: Wm C. Brown Company, 1967.
- Environmental Studies Center, Gulf Islands National Seashore. "Santa Rosa Island Beaches." Florida Dept. of Education, Office of Environmental Education.
- Green, Edna R., and Smallwood, William L. Laboratory Investigations in Biology. Morristown, New Jersey: Silver Burdett Company, 1968.
- Hungerford, Harold R. Science and Conservation in the Field. J. Weston Walsh, Publisher, 1969.
- Interaction Science Curriculum Project. Interaction of Man and the Biosphere. Chicago: Rand-McNally and Company, 1970.

Laun, H. Charles. The Natural History Guide. 2nd ed. Alton, Illinois: Alsace Books and films, 1967.

Outdoor Biology Instructional Strategies. U.S.A.: University of California, 1973.

O'Toole, Kathleen. Classnotes from Marine Biology Course taught by Mariscal at the Florida State University, 1974.

Rabinowitz, A.; Sutton, T. B.; and Taylor, E. M. Oceanography: An Environmental Approach to Marine Science. Lodi, New Jersey: Oceanography Unlimited, Inc., 1970.

Smith, R. I. Ecology and Field Biology. 2nd ed. New York: Harper & Row Publishers, 1974.

"Sourcebook of Marine Sciences." NDEA Special Project, Florida State Department of Education, 1968.

Storer, Tracy I., and Usinger, Robert L. Laboratory Manual for Zoology. New York: McGraw-Hill Book Company, 1958.

"Student-Teacher Environmental Relationships Investigations." ESEA Title III, Board of Public Instruction for the City of Savannah, Georgia, 1974-75.

Youthbook Conservation Corps Sourcebook for Environmental Awareness. "People and Natural Resources." Summer, 1977.

PART TWO

STUDENT'S GUIDE - GENERAL

I. TO THE STUDENT

"No species lives everywhere. Some are widespread, and some are found only in a few places; some are living on earth today, and some have become extinct. Nor are species scattered helter-skelter over the earth. Different species live in different places and at different times. That whales do not live in Nebraska today, that echinoderms live only in the seas and apparently never lived elsewhere, that palms once lived in Greenland, that the bacterium of tuberculosis lives in man and cows but not in dogs - all these are facts of distribution. Some are obvious facts; some are facts that have been established only after much patient searching for evidence. But do these facts make any sense?

"Cyril N. Hinshelwood, a British scientist, has said, "Science is not the mere collection of facts, which are infinitely numerous and mostly uninteresting, but the attempt of the human mind to order these facts into satisfying patterns."⁷

This booklet was designed to guide you in a search for biological patterns that you've probably never noticed right here in Franklin County. It is suggested that while working through the unit, you answer all questions, take notes, and record all observations and data in your biology databook. It should at all times be neat, accurate, and complete.

Please do not write in this book.

II. THE ECOSYSTEM

Some Basic Principles.

During the past several years, the word "ecology" has become an extremely popular word. Unfortunately, very few people who use it actually know and understand its true meaning. The word was coined by a German biologist named Ernst Haeckel. In German his word was ökologie, from the Greek word oikos, which means "household" or "place to live".⁸ Haeckel gave the word "ecology" the meaning that scientists still use today. The study of ecology deals with the relationship between an organism and its place to live - its environment - both living and nonliving.

All organisms, of course, live in the biosphere - that thin layer covering the surface of the earth in which life is possible. But the entire biosphere is too large an area for ecologists to study. Therefore, in order to fully understand this delicate balance between each living thing and its environment, scientists study small pieces of the biosphere. Each of these small pieces of biosphere, called ecosystems, is an efficient system in which organisms interact and depend upon each other and upon their nonliving environment.

An ecosystem may be any size. It may be a forest, a meadow, a pond, or a classroom aquarium. But all ecosystems have something in common. Each consists of two interacting parts: the biotic (living) environment and the abiotic (nonliving) environment. The biotic portion, of course, includes all plants, animals, and protists. The abiotic portion of an ecosystem includes such things as soil, climate, topography, amount of light, wind, and moisture. An ecosystem extends only as far as its special combination of biotic and abiotic characteristics exists. When these

change, that particular ecosystem ends, and another begins.

"Notice the acorn with the hole in its side. The inside of the acorn is an ecosystem. Some insect made the hole, and other organisms now live inside the acorn - probably some microscopic bacteria, possibly some fungi (plants), perhaps some single-celled organisms...possibly a worm or an insect. And inside the acorn there is certainly a different physical [abiotic] environment from that outside: dark, not windy, probably moist, warm or cool, and acidic (because there is tannic acid in acorns).



"An acorn is a tiny ecosystem. But the biosphere is filled with all sizes of ecosystems, each of which includes complicated relationships. An ocean is a big ecosystem; a lake is a smaller one. The North American grassland from Canada into Mexico is an extensive ecosystem..."⁹

As a matter of fact, this school is an ecosystem.

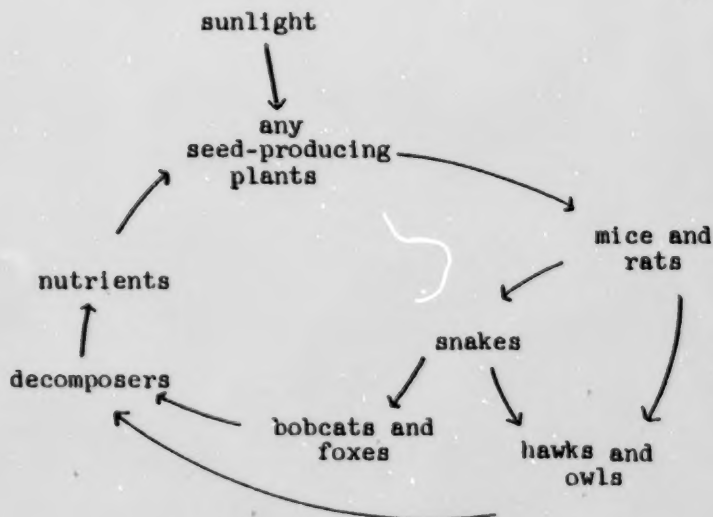
The Biotic Community.

One logical way of looking at the biotic portion of an ecosystem is to divide its entire group of living things into three groups: producers, consumers, and decomposers. An organism is a consumer if it must eat plants and other animals to obtain nourishment, and therefore energy, to carry on its life activities. If it feeds only on plants, it is called a first-order consumer. If it feeds on first-order consumers, it is a second-order consumer, and so on. But all energy used by consumers originally came from green plants. Where do green plants obtain their energy? They take it from sunlight.

Green plants use sunlight (light energy), along with water and carbon dioxide from the air to produce high-energy sugars. Only green plants can do this. Therefore, they are called the producers of an ecosystem.

If it weren't for the last group of organisms, the decomposers, plants would continue to use water, carbon dioxide, and many important minerals from the biosphere until they were used up. Decomposers, therefore, perform a vital task. They feed on dead organic matter and wastes, decomposing it (breaking it down), and returning all these materials to the environment. Microscopic organisms such as bacteria and yeast, as well as snails and many fungi, are decomposers.

The members of these groups are tied together in food chains, and food chains interconnect to form food webs. Every ecosystem has many characteristic food webs. A typical food web which might be found in a pine forest ecosystem is shown in the following diagram.¹⁰



The Abiotic Environment.

No living thing could exist without the abiotic portion of the environment. Rain or moisture, along with carbon dioxide and sunlight are necessary for green plants to produce high-energy sugars - a process known as photosynthesis. They also require nitrogen in order to synthesize (put together) proteins, which are the major building blocks of plant and animal cells. Soil supports and provides important nutrients for plants. Animals must have oxygen for respiration and water for a variety of bodily functions. Most chemical reactions which occur within the bodies of plants and animals are possible only within a certain temperature range. In addition, such abiotic factors as wind, water current, and soil type will also help determine whether or not a biotic community can exist in a particular place.

Man and the Ecosystem.

R. L. Smith provides an excellent beginning point for a discussion of man's effect on the biosphere. He asks you to imagine a spaceship visiting earth for the first time:

As they approach the earth in the spacecraft, the occupants must be impressed with the imprint of man on the planet. No matter what ecosystem one observes, he cannot escape the presence of that one dominant organism. For miles his domination is revealed by the layers of dust and smog that blanket much of the earth. As one gets closer one can see the results of the ameboid growth of human populations stretching across the land. Large areas of natural vegetation have been transformed into patterns of croplands; free-

flowing rivers have been dammed to create enormous lakes. Mountains and hills have been pared away for the exploitation of minerals; refuse and debris of modern civilization litter the planet. In places the landscape still remains wild; in places it has been humanized; and in other places it has been ravished.

This is the visible impact of man. Not so noticeable are the more subtle changes he has brought about. He has introduced excessive quantities of certain elements such as mercury, lead, and cadmium into the biogeochemical cycles. He has added synthetic materials such as chlorinated hydrocarbons to which organisms had never been exposed.

In his nearly two billion years of occupancy of the earth, man has been molding the planet to his own designs...¹¹

What happens when one part of the complex interwoven web of life in an ecosystem is changed? Obviously, if all the green plants were removed, the sun's energy would no longer be available for the consumers and they would soon die. The entire ecosystem would stop functioning. But milder measures, such as the use of a pesticide to do away with a certain insect pest, will have an equally harsh effect on an ecosystem. The organism dependent upon that insect, possibly a bird or reptile, may be killed by eating its poisoned prey, or by starvation. As the effects of his environmental manipulation move along the food chain, man becomes his own victim. In his hurry to control the environment to his own advantage, he often forgets that he is also a dependent organism and a part of the biosphere. It is crucial, therefore, that man develop an awareness of the ecological impact of his actions.

For Research.

1. Read and take notes on any two of the following recommended readings:
 - Biological Science Curriculum Study. Biological Science: An Environmental Approach. 3rd ed. New York: Rand-McNally & Company, 1973. Chapter 3.
 - Otto, J. and Towle, A. Modern Biology. New York: Holt, Rhinehart, and Winston, Inc., 1963. Chapter 49: "The Habitat" and Chapter 48: "Introduction to Ecology"
 - Green, E. and Smallwood, W. Biology. Morristown, New Jersey: Silver-Burdett Company, 1968. P. 657-669.
 - Enger, Gibson, Kornelink, Ross and Smith. Concepts in Biology. Dubuque, Iowa: Wm. C. Brown Company, 1976. P. 305-316.
2. View the filmstrip entitled "Community Food Energy Flow," in the kit entitled Ecology: Interrelationships in Nature. Chicago: Society for Visual Education, 1974.
3. Distinguish between an ecosystem and a community.
4. How can organisms living in the same place be said to occupy different niches?
5. Find out all you can about the processes of photosynthesis and respiration. What is the relationship between the two processes? Why are they important in the functioning of an ecosystem?
6. Explain the statement; "No organism lives alone."
7. What is the difference between a predator and a parasite?
8. What is the difference between commensalism and mutualism?
9. Why do you think it is impossible to draw a sharp boundary between two ecosystems?

Zonation.

"The habitat of an organism is the place where it naturally lives. It is the usual environment of an organism, and it includes both living and non-living characteristics. For example, the habitat of an alligator is a southern swamp which has lush vegetation and slow-moving warm water.

"Some kinds of organisms can live only in a special habitat. That is they require certain environmental conditions for life and growth. Barnacles must live attached to a hard surface which is between high tide and low tide and is wetted by salt water. Other animals can live in a broad habitat. For example, gray squirrels live in the forests of the coast, the Piedmont, and the Appalachian Mountains...

"Often a large biological community...can be subdivided into several smaller physical zones. For example, in a forest there is the canopy zone where the tall trees spread their branches, the shrub zone, the sub-surface zone where dead leaves accumulate, and the soil zone itself. Each of these zones has a different set of environmental conditions such as wetness, light, nutrients, and temperature.

"Zonation refers to the fact that a biological community can be divided into particular zones or habitats. When you study the patterns of animal and plant distribution...you are really studying zonation."¹²

III. THE GOAL

Your group's objective is to produce a neat, organized, and informative booklet about the aquatic ecosystem identified for you by your teacher. You will compile the raw material for this booklet through field studies, laboratory work, and library research. Throughout the study you will be working in a group of from five to ten students, depending upon the size of your class. Remember at all times that these students are depending on you to carry out your designated responsibilities accurately, completely, and on time. One nonproductive member of a group greatly effects the quality and amount of work which can be produced by the group as a whole.

The remainder of this book is designed to guide you through your study of an aquatic ecosystem. If you have any questions as you work through the study, do not hesitate to consult your teacher for help.

It is the responsibility of your group to read the material and decide how you are going to divide up the necessary work. Your group must also arrange to meet periodically with your teacher for approval of plans and consultation.

PART THREE
RIVERS, LAKES, AND PONDS

I. INTRODUCTION

This portion of the package was designed to guide the student through an in-depth study of a fresh-water ecosystem: a river, a lake, or a pond. Your teacher will decide which of the three your group will be studying. Although each has characteristics which make it different from the others, all three fresh-water ecosystems can be grouped together based on certain common characteristics.

What makes inland-waters, the great majority of which are fresh-water ecosystems, different from ocean waters? Ocean waters on earth form one large interconnected water system which surrounds all the continents and which undergoes a regular daily change in water level, due to the influence of the sun and moon. These changes, of course, are called tides and they are not normally found in inland bodies of fresh-water. The oceans contain a large amount of dissolved minerals and salts and organisms which have become adapted to living in the salty solution. On the other hand, fresh-water bodies of water generally exist on the surface of the land, and due to their height above sea level, tend to flow steadily downward and towards the sea. They normally contain a much smaller amount of dissolved minerals than do oceanic waters.¹³ And, of course, these inland waters are homes for organisms which, for the most part would not be able to adjust to the oceanic environment.

The study of the biology of fresh-waters is known as limnology, and scientists who are trained for this study, called limnologists, have divided fresh-water ecosystems into two groups: lentic or standing-water habitats, and lotic, or running-water habitats.¹⁴

Lentic Ecosystems.

This group includes all fresh-water areas in which little water movement occurs: lakes, ponds, fresh-water marshes, swamps, and bogs. Lakes differ from ponds in that ponds are shallow enough for some sunlight to penetrate all the way to the bottom, whereas lakes generally have bottom depths where no light can penetrate. Temperature in both usually varies with the season and with the depth, and they usually contain less dissolved oxygen than do bodies of running water.

Energy producers (remember, green plants?) in a lentic ecosystem are many. The most important ones, however, are not the larger cattails and waterlilies that you would expect. Far more food production is carried on by plant plankton.

The term "plankton" refers to all of the small, mostly microscopic, plants and animals that drift suspended in water (ocean waters, as well). Plant plankton, the producers, are referred to as phytoplankton. And of course, they all contain chlorophyll for photosynthesis. Many kinds of algae are phytoplankton. Most of the first-order consumers in this ecosystem, that is, organisms that feed directly on the phytoplankton producers, are also plankton - the animals or zooplankton. And all the planktonic organisms serve as food for larger animals in the lentic ecosystem.

Lotic Ecosystems: Brooks, Streams, and Rivers

The most outstanding feature of streams and rivers is current or continuously moving water. This movement influences both biotic and abiotic factors of the lotic ecosystem. Plankton cannot survive swift currents and so are usually not found in fast-moving brooks and streams. Food production

in these places is limited to algae growing attached to rocks on the sides and bottom of the stream. The amount of dissolved oxygen, on the other hand, is usually higher than in lakes and ponds due to the tumbling of water through rapids and falls, a process which traps small bubbles of air and allows the oxygen to dissolve.

As brooks form streams and streams join to form rivers, the water begins to move more slowly. The slower the water movement, the better the environment for the survival of plankton. More sunlight reaches the surface of the water as the rivers become wider and trees no longer shade large areas of the surface. Rooted plants are better able to survive in this slow current also. The characteristics of large river ecosystems begin to more closely resemble those of lakes and ponds.

For Research.

1. Read and take notes on one or both of the following recommended readings in the library.
 - Amos, W. H. "Teeming Life of a Pond." National Geographic Magazine, August, 1970, pp. 274-298.
 - Amos W. H. "Unseen Life of a Mountain Stream." National Geographic Magazine, April, 1977, pp. 562-580.
2. View the filmstrip entitled, "Organisms Living Together in Communities," in the kit entitled Ecology: Interrelationships in Nature. Chicago: Society for Visual Education, 1974.
3. How does the source of dissolved oxygen differ in a brook, a slowmoving river, and a lake?
4. In the course of a year, many lakes and ponds undergo seasonal changes in temperature. A

definite mixing occurs, called an overturn. Investigate and take notes on this process. How does it affect the oxygen content at different depths?

5. Where would you expect to find the decomposers (bacteria) most abundant in a lentic ecosystem?
6. Lakes and ponds can also be divided into zones based on the depth to which light penetrates. Find out as much as you can about these zones.
7. How are lakes, ponds, and rivers formed?

The reference list at the end of this booklet contains a number of sources in both the library and the classroom which should be of considerable help to you in researching the above topics.

II. CONDUCTING THE STUDY

Equipment List for Rivers, Lakes, and Ponds.

- | | |
|---|---|
| 1. General | |
| 25 wooden stakes | elastic bands |
| 3 balls of string or heavy cord | metric rulers |
| 6 one-square-meter quadrats (made of strips of wood lath) | pocket magnifiers |
| 6 meter sticks | identification guides |
| 3 test tubes (no lip) | 10% formalin |
| 3 corks to fit t.tubes | carbon tetrachloride |
| detergent | cotton |
| clear tape | enamel pans |
| drawing paper | forceps |
| | dip nets |
| | seine net |
| | stream-bottom sampler (rake with burlap bag attached) |
| 2. Plants | |
| pencils & notebooks | insect nets |
| 3 x 5 notecards | field glasses |
| assorted bottles & jars | dissecting microscope |
| masking tape | |
| plastic bags | |
| elastic bands | 4. Plankton |
| metric rulers | plankton net |
| pocket magnifiers | jars |
| identification guides | culture dishes |
| graph paper | eye droppers |
| plant press (optional) | slides |
| | depression slides |
| | cover slips |
| 3. Animals | microscopes (compound and dissecting) |
| 3x5 notecards | cedar oil |
| pencils & notebooks | transparent metric rulers |
| assorted bottles & jars | |
| masking tape | |
| plastic bags | |

methyl cellulose
 various stains
 plankton net to make
 rope fishline
 weight swivel
 canvas stocking
 embroidery hoop
 collecting jar
 (see Laun, Natural
 History Guide, p.92)

5. Abiotic
 notebook & pencil
 thermometers
 anemometer
 jars with lids to fit
 water sampler (to make)
 cork bricks
 eyebolt string
 plastic jug
 dissolved oxygen test
 kit
 pH test kit
 secchi disc
 oven

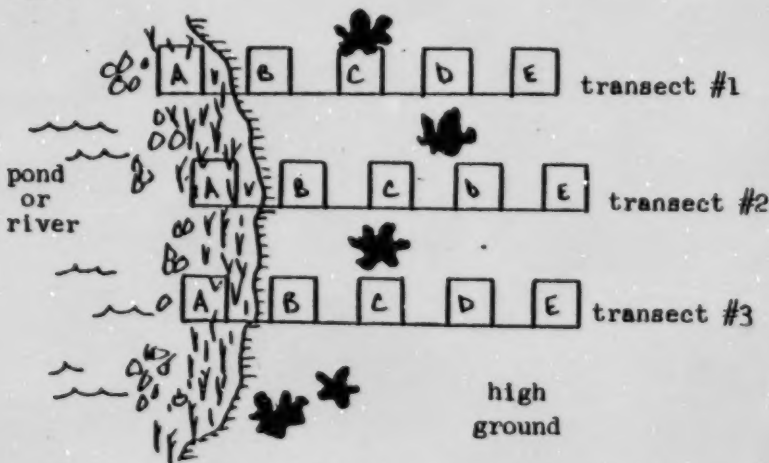
Task One: Setting Up a Study Area.

When scientists study an ecosystem or community, they try to analyze it in as much detail as possible. This involves observing, identifying, measuring, and counting in the hope of discovering some pattern. He or she is looking in particular for patterns of plant distribution, patterns of animal distribution, and patterns of environmental factors (abiotic). This is also what you are attempting to do in your study of the pond or river. In order to discover distribution patterns, you need to count and identify organisms in each section of the pond or river bank. But it would be almost impossible to count all the cattails, for instance. Instead, you will work with samples and sampling techniques which have been developed to give very accurate estimates in a much shorter time period.

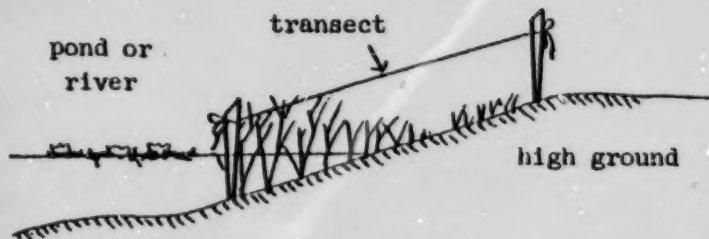
The sampling technique you will be using in this particular study is called the transect method. Necessary materials are listed in the Equipment List under "General" on page 28.

A quadrat is a wooden frame which when placed on the ground covers one square meter (1 m^2). Your counting of organisms will be limited to those more than halfway inside the quadrat.

To sample an area accurately, you place the quadrat in a regular pattern along a straight line, called a transect line. If you were to be in a plane looking down, the transect would look like this:



You will be constructing three transects. Begin in the water by finding the point at which the first rooted plants appear. Drive a stake into the ground at that point and tie one end of the string to it. Now walk directly away from this stake up the bank to a point exactly nine meters from the first stake, and drive a second stake into the ground. Pull the string taut and tie it to the second stake, as shown in the diagram below:



Now set up another transect approximately five meters from the first, and another ten meters from the first, so that the three transects are positioned like those in the diagram on page 30.

To begin the sampling, drop the quadrat beside transect #1 with the corner of the quadrat against the first stake (quadrat station A in the diagram). Then carry out your planned activities (plant and animal counts and recording of abiotic factors to be discussed later). When you finish at this station, take your equipment and move down one side of the transect until you come to station B. There should be a distance of one meter between stations.

Continue in this way through all five stations on each of the three transects.

Task Two: Slope of the Pond or River Bank

See Appendix C for directions for measuring slope. You are responsible for assembling equipment, taking it to the study site on the day of the field trip, and using it to measure and record the slope on graph paper. Begin measuring at the water's edge and move away at one meter intervals. You may want to designate a group member to practice using the apparatus on a hill or slope near the schoolgrounds.

The slope data recorded at the study site will be used later to show a cross-section of the area vegetation (plant life). Accuracy is extremely important.

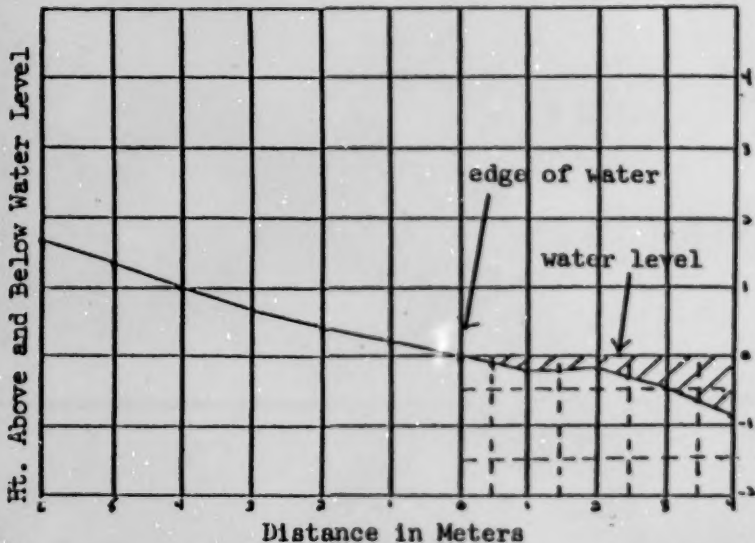
Task Three:

Bottom Topography

Beginning at the water's edge, record water depth at one-half meter intervals in the direction of the pond's or river's center.

This can be done easily by attaching a string to a stake at the water's edge, and slowly backing away into the water, measuring water depth with a meter stick every one-half meter. It might be helpful to tie knots in the string at half-meter intervals before going into the field.

This data can be added to that obtained from slope measurement above, yielding an accurate diagram of the study site topography in cross-section as in the diagram below.



Task Four:**Vegetation Study (Plants).****A. Before the field trip:**

- Become familiar with the types of plants you may expect to find at a pond or river by looking through identification manuals, etc.
- Construct any special equipment and gather together all necessary materials so that you'll have them when you get to the study site.
- Make 3 copies of the Transect Data Sheet shown below to take on the field trip for the recording of data.

Transect Data Sheet					
Vegetation	Transect # _____				
Species	A	B	C	D	E
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
↓ etc.					

- Fill out ten or fifteen 3 X 5 file cards as shown on the next page.

Scientific Name	_____
Common Name	_____
Height	_____ Weight _____
Color(s)	_____
Identification Book	_____
Where found	_____
Other information	_____

(from Neal Berger, "Environmental Management Study Area" (Florida Dept. of Education, Office of Environmental Education, Minigrant 1974-75) p.16)

-Begin research on a report about fresh-water vegetation using information you find in the library or in the sources listed at the end of this book. Your report should cover such things as the types of vegetation associated with different bodies of water (ponds, lakes, rivers, bogs, swamps, etc.), plant zones of a pond or lake, changes in a plant community over a period of time, and possibly special adaptations of water plants.

B. At the study site:

Start at quadrat station A of transect #1. What appears to be the most abundant plant species in the quadrat? Try to identify this species using one of the identification guides. When you have correctly identified it, record all important information about it on one of the file cards you brought along. It would also be a good idea to make a quick accurate sketch on the back of the card. Then count all the individuals of that species in quadrat A and record this information in the appropriate place on the Transect Data

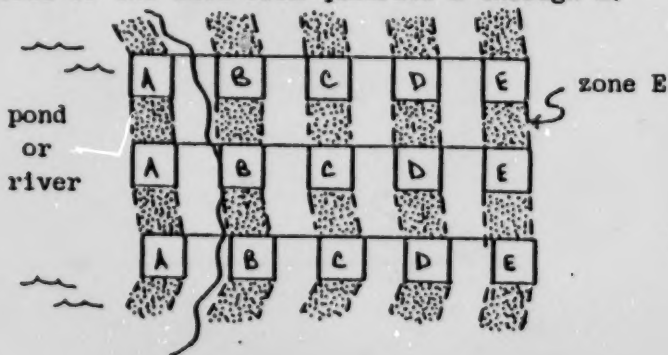
Sheet for transect #1. If you cannot or don't have time to properly identify the plant, designate the unknown species with letters or numbers. Make sure to take a properly marked sample back to the lab for proper identification later on. See Appendix D for suggestions on collecting.

Continue identifying and counting all species of plants found in quadrat A, recording information on the Transect Data Sheet, and on separate file cards. When you have finished quadrat A, move on to B, then C, and so on, and then complete the other two transects as well, until you have data on the vegetation in all fifteen quadrats.

C. After the Field Trip:

- Identify all unknown vegetation, using a hand lens and identification manuals. Fill in this information on appropriate charts and file cards.
- In order to find out if any zonation or patterns of plant distribution exist in the study area, you must organize your raw data and graph it in such a way that these patterns become obvious.

Imagine first that all three quadrats at the A position on the three transects are samples of zone A of the pond or river. Then all the data from quadrat station A, when grouped together, may tell us something about zone A. And the same is true of the data from quadrats B through E.



You have samples from five distinct zones of the pond or river bank. Now you will see what you can find out about them.

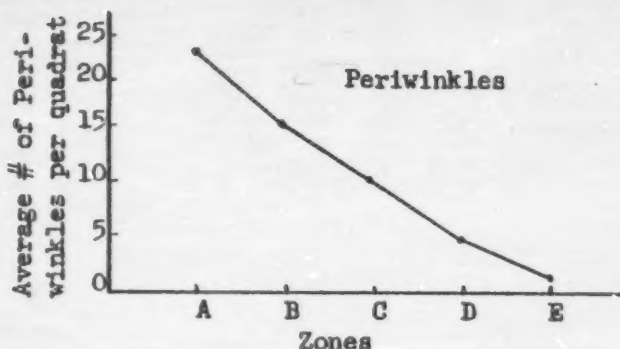
First use the method shown below to find the average number of individuals per quadrat for each species. The example is for periwinkles in a marsh.

Species: Periwinkle					
	Zones				
	A	B	C	D	E
Transect #1	18	10	8	4	0
Transect #2	31	20	11	6	4
Transect #3	20	15	11	5	2
Total =	69	45	30	15	6
Average per quadrat					
(Total) =	23	15	10	5	2
3					

Reading from the above chart, the average number of periwinkles per quadrat in zone A of the study site is 23, and so on.

Repeat these calculations for each species of plant you recorded finding at your study site.

Now plot graphs of your data, with the "Number of plants per quadrat" on the vertical axis, and "Plot" on the horizontal axis. You may plot each species on a different graph, or you may plot them all on the same graph, using different colors or different types of line for each species. The data given for periwinkles is plotted for you on the next page as an example.



When you have finished, take a good look at your graph(s). Do you see any obvious signs of zonation? Does one plant seem to dominate all zones or does each zone seem to have its own characteristic dominant plant?

- Using the formulas below, calculate the density (the number of plants of a certain species per unit area) and the frequency (the percentage of quadrats occupied by a certain species) of each plant species observed at the study site and record the calculations on a Vegetation Analysis Chart, for which an example is given.

$$\text{Density} = \frac{\text{total \# of plants of a certain species}}{\text{total area sampled (15 m}^2\text{)}}$$

$$\text{Frequency} = \frac{\text{the \# of plots in which the species occurs}}{\text{total \# of plots (15)}} \times 100$$

Vegetation Analysis Chart		
Species	Density	Frequency
1.		
2.		
3.		
4.		
etc.↓		

Which species had the highest density? Which had the highest frequency?

- Use all information obtained in this vegetation analysis along with the data from Tasks Two and Three (Slope and Topography) to draw a neat and accurate diagram of an imaginary cross-section through your study area, showing the contour of the land, water level, bottom topography, and dominant vegetation at each zone. Use graph paper for your diagram. Make sure you correctly label and title it.
- Describe the pattern of zonation you found on the pond or river bank. How do you think the dominant plant found in each zone is adapted to its particular environment. (Hint: the results of Task 7 may help.)
- Make a dichotomous key to the species of vegetation found at your study site.
- Suggestion: Use a plant press to preserve collected plant specimens.

Task Five: Animals

A. Before the field trip:

- Become familiar with the different groups of animals normally found in the pond or river ecosystem by looking through identification guides (see list of sources). This will help speed up the identification process on the field trip.
- Gather together all equipment and materials needed to collect, identify, and preserve animals at the study site. You will need to bring along a killing jar for any insects which cannot be identified in the field. Directions for constructing an insect killing jar are given in Appendix B. Also be sure to bring along a sufficient amount of 10% formaldehyde (your teacher will have it made up for you). This is used to preserve small animals

for later study.

- Prepare file cards for animal species following the format shown in Task Four above.

B. At the study site:

The process of counting and estimating density and population size for animals is much more complicated than for plants because animals can move. Therefore, in this study you will be observing and identifying as many pond or river animals as you can, but you will not need to make counts of these animals.

Use the available equipment to find as many different animal species as you can. Remember to include all animals that seem to be a part of the pond community, whether they live in the pond or not. Flying insects may be trapped with a large net. You may also use a net to catch insects on the surface of the water and those hiding on water plants. Pulling the seine through the water usually nets many different types of fish, tadpoles, and other swimming animals. If you are sampling in a river, try turning over rocks and stones upstream from the net. Use the stream-bottom sampler to stir up and net bottom-dwelling organisms. Or scoop up samples of bottom mud, spread it in white enamel pans and sort through it looking for small bottom-dwellers. And don't neglect the birds - you should be able to make some positive identifications using a pair of field glasses.

It may be helpful to use white enamel pans and forceps, along with a hand lens, to examine insects and other small organisms closely. If you can identify the animal on the spot, fill out a species card on it, and return it to the place where you found it. If you're having trouble identifying it, bring it back to the lab for later identification. Use the killing jar for insects

and the formaldehyde for larger animals. Then place the organisms in plastic bags or jars which have been properly labeled with any information which may be helpful to you later on.

C. In the laboratory:

- Finish identifying all previously unknown organisms which you have collected and brought back using identification manuals listed in the reference section at the end of this book. Fill out species file cards completely, including an accurate sketch on the back of the card.
- Make a dichotomous key to the organisms you observed.
- Research: what are some ways pond or river animals are adapted to their environment?

Task Six: Plankton

A. Before the field trip:

- research phytoplankton and zooplankton thoroughly.
- read about one-celled organisms and the structures normally found in their bodies.
- gather together the necessary materials to take on the trip. In particular, be sure you have the plankton net and a number of collecting jars.

B. At the study site:

- Take the plankton net and a number of jars to a place at the edge of the pond or river from which the net can be cast. Fill each jar about one third full of pond water.
- Take a number of samples by casting the net out into the water and pulling it back in. Pulling it fast will keep it near the surface of the water. To sample a deeper-water zone, cast the net, allow it to sink to the desired depth, and then

pull it slowly back. You should sample both the the surface-water zone and deep-water zone. Each time you pull the net in, remove the bottle from the net, and empty its contents into a jar. The jars should be properly labeled for surface- and deep-water zones. If you must wait at the study site for any length of time, place your samples in the shade or the heat of the sun will kill the pond organisms.

C. Back in the laboratory:

- Pour the contents of each jar into a petri dish.
- Use the dissecting microscope to observe larger macroscopic organisms. Focus at different levels of water, checking under the leaves of aquatic plants and the bottom of the dish.
- Transfer samples from different levels to slides, cover with cover slips, and examine under low and high power of the compound microscope. You may also want to observe samples on depression slides or using the oil immersion lens. Try to identify (scientific name) each different type of microorganism you find, using the references listed at the end of this book. Then make accurate neat drawings (see Appendix A) of each and measure (BSCS - Green Version has excellent directions for measuring with the microscope). For each one-celled organism, try to identify, draw, and label various structures that you observe in the cell. The nucleus may be observed by staining with methyl green (this will kill the organism, however). If you are having trouble observing a fast-moving animal, there are a number of techniques for slowing them down (see Paul Brandwein, Sourcebook for the Biological Sciences, p. 111-112).
- Learn how to culture pond organisms by reading pp. 120-122 of Exploring Life Science, by Thurber

and Kilburn, and Chapter 12 of Sourcebook for the Biological Sciences by Paul Brandwein. Set up pure cultures of various protozoa that you observed, following the directions given in these references.

- Did you see any difference in the number or types of organisms found in your surface-water and deep-water samples.
- Write a brief report about fresh-water plankton and attach your lab drawings. Then make a dichotomous key to the organisms you identified.

Task Seven:

Abiotic Factors

A. Before the trip:

- Gather necessary equipment and prepare necessary data sheets.

B. At each quadrat station on one transect:

1. temperature - use a centigrade thermometer to measure the air temperature and the soil temperature at each station.
2. wind - measure the wind velocity and direction at different heights above the ground. There are directions for constructing an anemometer in Terrestrial Ecology, by Andrews.
3. soil - take a sample of surface soil from each quadrat and put it in a sealed marked jar to take back to the lab for analysis.

C. At various water depths:

(To measure the following factors, you will need some type of water sampler. You may use one designed for that purpose, or you may construct one using the instructions in The Natural History Guide by Laun, p. 91.)

1. temperature
2. oxygen content - use an oxygen test kit to

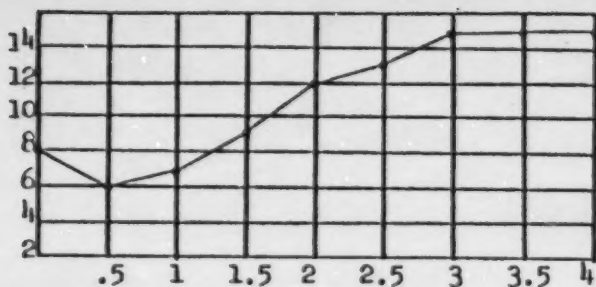
measure the amount of dissolved oxygen at regular depth intervals. You must be particularly careful not to jostle or splash your sample before you measure. Otherwise you will alter the oxygen content.

3. pH (acidity) - use a pH test kit for these measurements. Use the library to find out what pH is and why the proper pH is important. What can change the pH of a body of water?
4. turbidity - measure light penetration using a secchi disc. There are excellent directions for the use of a secchi disc on p. 91 of The Natural History Guide by Laun.

D. If you are measuring a stream or river, devise a way to measure stream flow, or use the method suggested in The Natural History Guide by Laun, p. 107.

E. Back in the classroom/laboratory:

1. soil - measure the amount of soil moisture, organic content, and pH for each sample brought back. Soil Ecology by W. H. Andrews, gives easily understood directions for all three.
2. Plot graphs with each of these environmental factors on the vertical axis, and quadrat station or water depth on the horizontal axis. This makes it easy to spot any relationships between environmental conditions and plant populations. An example of such a graph is shown below.



Water Depth in Meters

3. Try to relate your findings in this section to the pattern you found in plant and animal life as you moved from zone to zone up the stream or pond bank.

Task Eight: Food Webs

Draw one possible pond or river food web using the organisms you collected or identified.

Task Nine: Man

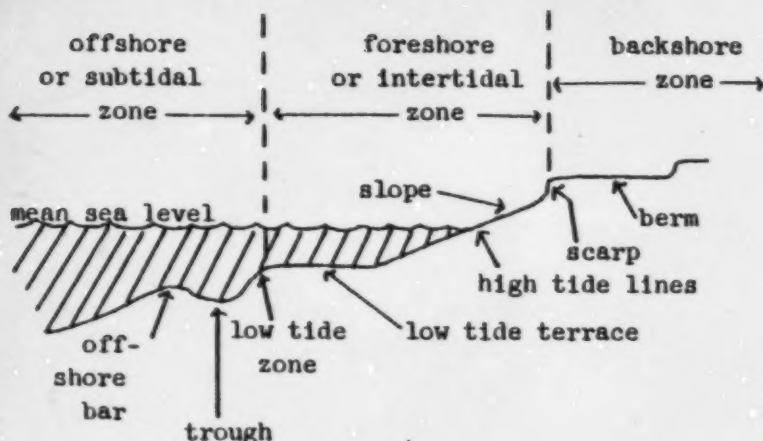
Research the importance or impact that man has on fresh-water ecosystems. Why are these ecosystems important to him, what is he doing to destroy them, and what is he now doing to prevent this destruction?

PART FOUR
SANDY BEACHES

I. THE SANDY BEACH ECOSYSTEM

"To know the edge of the sea is to know some of life's richest natural phenomena, to know man's deepest spiritual needs and moods, for our continental 'edges' are haunting places, studded with strange beauty, adaptive form and fascinating life. One moment tranquil, the next wild and unharnessed, the sea's edge has much to offer who seek its treasures. Of all the places in the world where plants and animals live, no region is richer, more varied, more prolific than the watery world of the edge of the sea. More than eighty-five percent of all the plants and wild creatures that have been identified on earth are found along the edge of the sea. This booklet can touch only lightly on what can be seen there, the history of the shores, its varied environments and peculiar life and non-life relationships, and why we should know and visit these areas."¹⁵

Every beach has a definite structure and obvious features most of which can be readily identified at any site. The beach is generally divided into three broad areas: the offshore or subtidal area, which is below the level of the lowest tide and is always submerged; the foreshore or intertidal zone, an area which is periodically flooded by salt water as the tide rises and falls; and the backshore or supralittoral zone, a transitional area where the environment changes from a water to a land ecosystem.



Offshore zone: Always submerged, it may consist of an offshore bar, which is a flat plain of sand that tends to break the force of the waves, and a trough which was dug by waves during higher' tides. The bar is usually built of materials dug from the trough by wave action.

Foreshore (intertidal area): At its upper edge is a short sharp drop called a beach scarp. This ledge is caused by waves during storm periods. The smooth flat beach beside the water is called the slope. You can usually find the high tide mark by looking for the driftline - the line of "beach wrack" or dead seaweed, shells, and other debris which was left by the tide as it started to recede. This portion of the intertidal area is submerged little during the year. As you move down the slope toward the water, the sand becomes wetter and more firmly packed. The lowest portion is exposed to air only during extreme low tides.

Backshore: Completely above water level, this portion usually consists of a flat area above the scarp called the berm and then a line of dunes or some other prominent feature of the coastline.

"Sandy beaches...are areas of constant change and motion. Every wave lifts and moves quantities of the sand. The breakers pound the shoreline ceaselessly. The tides move up and down the beach in daily, monthly, and annual rhythms and progressions. Exposed sands are subjected to direct sunlight, drying, wind transport, rain, and freezing. Floating objects, masses of seaweeds, and subtidal animals torn from their anchorages offshore by the turbulence of storms are cast ashore and pushed to the upper part of the beach by the waves of the highest tides. Each level of the beach is submerged and exposed for different amounts of time and at different times of day or night each successive day. High tides bring with them certain predators from the fringe of the sea, and low tides bring another set of hungry predators from the land.

"Only specialized animals can live successfully and maintain themselves in this turbulent world."¹⁶ In order to survive, most animals evade these dangers by burrowing. But sand is unstable - waves soon erase any trace of a burrow. So animals that live in sand must be able to reburrow immediately if they are exposed. They must also be able to reestablish contact with water rather quickly. Because of this common burrowing adaptation, what appears to be a barren stretch of beach is actually teeming with animals living ten or twelve inches below the surface.

Only recently discovered are the numerous 'interstitial fauna and flora' - those microscopic plants and animals which live in the film of water around and between the grains of sand. They are found most often in the sand of the lower beach where they receive maximum light, but suffer little risk of desiccation (drying out). And, of course, these organisms must also be adapted to the specific set of conditions under which they live.

For Research.

1. Research sand. Where did the sand on our beaches originate? How did it get here? What is it made of? What is the relationship of sand grain size to steepness (slope) of the beach?
2. Franklin County has three islands - Dog Island, St. George Island, and St. Vincent Island - which form a protective barrier to the shoreline. These islands are called barrier islands. Similar barrier islands can be found all along the Gulf Coast. Find out how barrier islands are formed and why they are constantly changing.
3. Read and take notes on the following article: Amos, William H. "The Living Sand." National Geographic Magazine, June, 1965, pp. 820-833.
4. View any two of the following filmstrips in the library and take notes on them:
 - "Seashore Interaction of Two Communities" in the kit Ecology: Interrelationships in Nature. Chicago: Society for Visual Education, 1974.
 - "Life in a Sand Dune Succession" in the kit Modern Biology: Environment and Survival. Chicago: Society for Visual Education, 1974.
 - "Life of the Sea Floor and Shores" in the kit Understanding Oceanography. Chicago: Society for Visual Education, 1966.

II. CONDUCTING THE STUDY

Equipment List for Sandy Beaches.

1. General

25 wooden stakes
3 balls of string or
heavy cord
6 one-square-meter
quadrats (made of
strips of wood lath)
6 meter sticks
3 test tubes (no lip)
3 corks to fit t. tubes
detergent
clear tape
drawing paper

2. Plants

pencils and notebooks
3 X 5 notecards
assorted bottles & jars
masking tape
plastic bags
elastic bands
metric rulers
pocket magnifiers
identification guides
graph paper
plant press (optional)

3. Animals

3 X 5 notecards
pencils and notebooks
assorted bottles and
jars
masking tape

plastic bags
elastic bands
metric rulers
pocket magnifiers
identification
guides
10% formalin
carbon tetrachloride
cotton
enamel pans
forceps
dip nets
seine net
sieve set
insect nets
field glasses
dissecting micro-
scope

4. Plankton

long handled plankton
net
jars
culture dishes
eye droppers
slides
depression slides
cover slips
microscopes (compound
and dissecting)
cedar oil
transparent metric
rulers

methyl cellulose
 various stains
 aquarium pump
 airstone
 3-5% formalin
 plankton net to make
 rope fishline
 weight swivel
 canvas stocking
 embroidery hoop
 collecting jar

(see Laun, Natural
 History Guide, p.92)

5. Abiotic
- notebook and pencil
 - thermometers
 - anemometer
 - jars with lids to fit
 - dissolved oxygen test kit
 - pH test kit

secchi disc
 oven
 coffee can
 small shovels or
 scoops
 refractometer or
 hydrometer
 sieve set - sizes 5,
 7, 10, 32, 80, 250,
 and 325.

6. Microscopic forms
- 12 petri dishes
 - bunsen burners
 - 12 slides and cover
 slips
 - compound microscope
 - crystal violet stain
 - sterile sea water
 - inoculation loop or
 sterile Q-tips
 - grease pencil
 - 10 g. peptone
 - 52 g. agar
 - 33 g. dextrose
 - 1 g. Sol-U-Pro
 - 2 g. yeast extract
 - 200 ml Chloromycetin,
 Terramycin, or peni-
 cillin
 - autoclave
 - incubator (if avail.)

Task One: Setting up the Study Area

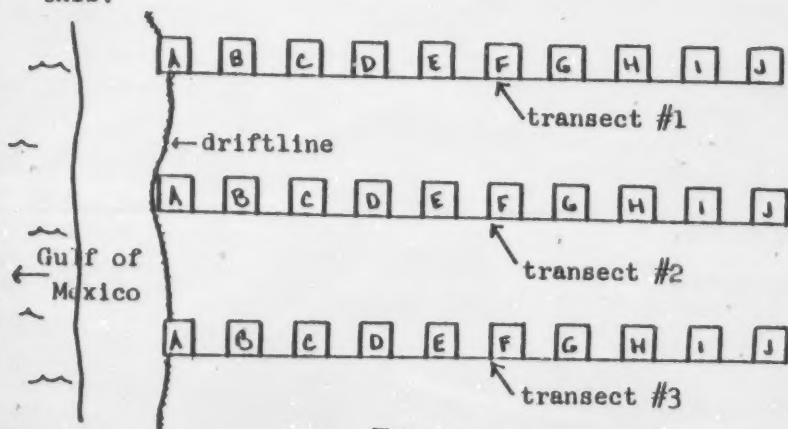
When scientists study an ecosystem or community, they try to analyze it in as much detail as

possible. This involves observing, identifying, measuring, and counting in the hope of discovering some pattern. He or she is looking in particular for patterns of plant distribution, patterns of animal distribution, and patterns of environmental factors (abiotic). This is also what you are attempting to do in your study of the sandy beach. In order to discover distribution patterns, you need to count and identify organisms in each section of the beach. But it would be almost impossible to count all the beach hoppers, for instance. Instead, you will work with samples and sampling techniques which have been developed to give very accurate estimates in a much shorter time period.

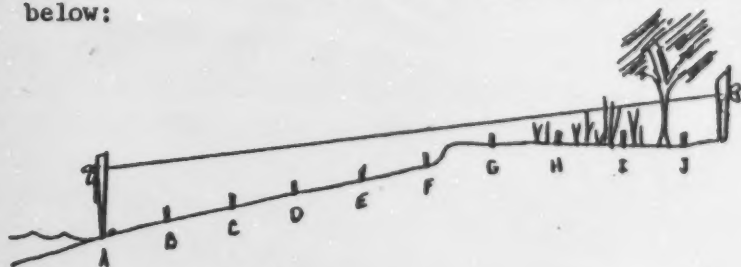
The sampling technique you will be using in this particular study is called the transect method. Necessary materials are listed in the Equipment List under "General" on page 50.

A quadrat is a wooden frame which when placed on the ground covers one square meter (1 m^2). Your counting of organisms will be limited to those more than halfway inside the quadrat.

To sample an area accurately, you place the quadrat in a regular pattern along a straight line, called a transect line. If you were to be in a plane looking down, the transect would look like this:



You will be constructing three transects. Begin at the driftline. Drive a stake into the sand at that point and tie one end of the string to it. Now walk up the beach to a point well into the dune line if this is a barrier beach, or, if it is a protected beach, to a point at which the vegetation consists mostly of heavy shrubs and trees. Drive a second stake into the sand. Pull the string taut and tie it to the second stake. Then divide the transect into ten sections of equal length, marking the sections with twigs or stakes. Quadrat station A will be located at the first stake, and quadrat stations B through J will be located at the beginning of each of the nine sections of the transect which remain, as shown in the diagram below:



Now set up another transect approximately fifteen meters from the first, and another thirty meters from the first, so that the three transects are positioned like those in the diagram on page 52.

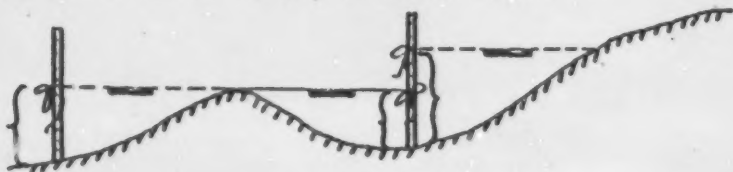
To begin the sampling, drop the quadrat beside transect #1 with the corner of the quadrat against the first stake (quadrat station A in the diagram). Then carry out your planned activities (plant and animal counts and recording of abiotic factors to be discussed later). When you finish at this station, take your equipment and move down one side of the transect until you come to station B, then Station C, and so on. Continue in this way through

all ten stations on each of the three transects.

Task Two:

Slope of the Beach.

See Appendix C for directions for measuring slope. You are responsible for assembling equipment, taking it to the study site on the day of the field trip, and using it to measure and record the slope on graph paper. Begin measuring at the water's edge and move away at one meter intervals. If you come to a rise that drops off into a little gully, you may find it useful to reverse your usual procedure temporarily. In such a case, put the end of the string at the new measurement point and run it out to the meter stick, as shown below:



Mark any of the beach features discussed on page 47 on your graph at a spot equivalent to where they actually occur on the beach.

You may want to designate a group member to practice using the apparatus on a hill or slope near the school grounds.

The slope data recorded at the study site will be used later to show a cross-section of the area vegetation (plant life). Accuracy is important.

Task Three:

Vegetation Study (plants).

A. Before the Field Trip:

- Become familiar with the types of plants you may expect to find on your beach by looking through identification guides, etc.
- Construct any special equipment and gather together all necessary materials so that you'll have them when you get to the study site.
- Make three copies of the Transect Data Sheet shown on page 33 to take on the field trip for the recording of data. However, you will have to alter this Data Sheet slightly to fit the beach study by adding columns for quadrats F through J.
- Fill out ten or fifteen 3 X 5 file cards as shown on page 34.
- Begin research on a report about marine vegetation using information you find in the library or in the sources listed at the end of this book. Your report should cover such things as the types of vegetation associated with marine ecosystems, beach plant zones, sand dune succession, and possibly special adaptations of marine plants.

B. At the study site:

The directions for this section are the same as for the pond study. See "B. At the study site" on page 34. You will have data on thirty quadrats rather than fifteen. In addition to these directions, collect as many types of seaweed (algae) as you can find floating in shallow water (0-2 meters). Put small portions of the algae in buckets or jars of salt water to take back to the lab.

C. After the field trip:

- The directions for this section are the same as for the pond study. See "C. After the field trip" on pages 35 through 37. You will have ten zones rather than five. Also, make species cards for each type of seaweed collected, making an

accurate sketch on the back of the card. If you have a plant press handy, try pressing and making herbarium mounts for your samples, using the directions given in The Sourcebook for the Marine Sciences, pp. 147-148.

- Which species on your Vegetation Analysis Chart had the highest density? Which had the highest frequency?
- Use all information obtained in this vegetation analysis along with the data from Task Two (slope of the beach) to draw a neat and accurate diagram of an imaginary cross-section through your study area, showing the contour of the beach, major features, and dominant vegetation at each zone. Use graph paper for your diagram. Make sure you correctly label and title it.
- Describe the pattern of zonation you found on the beach. How do you think the dominant plant found in each zone is adapted to its particular environment. (Hint: the results of Task Six may help.)
- Make a dichotomous key to the species of vegetation found at your study site.

Task Four: Animals.

A. Before the field trip:

The directions for this section are the same as for the pond study. See "A. Before the Field Trip" on pages 38-39.

B. At the study site:

The process of counting and estimating density and population size for animals is much more complicated than for plants because animals can move. Therefore, in this study you will be observing and identifying as many animals as you can, but you will not need to make counts of

these animals.

Use the available equipment to find as many different animal species as you can. Search immediately for any large animals which may move away. Designate two or three people to pull the seine net through shallow a few times. This should yield several species of small fish and invertebrates (many of which make excellent inhabitants for a salt-water aquarium if your class has one). At each quadrat, dig into the sand and search for small organisms who inhabit that portion of the beach. It may be helpful to put the sand into a white enamel pan and sort through it, or use a large mesh sieve to sift out these sand-dwellers. Flying and hopping insects may be collected with a net. And don't neglect the birds. You should be able to make some positive identification using a pair of field glasses.

If you can identify the animal on the spot, fill out a species card on it and return it to the place where you found it. If you're having trouble identifying it, bring it back to the lab for identification later. Use the killing jar for insects and the formaldehyde for larger animals. Then place the specimens in plastic bags or jars which have been properly labeled with any information which may be helpful to you later.

Devise a method for observing microscopic 'interstitial fauna'. To do this, you will probably have to bring back samples of wet sand from the lower beach.

C. After the field trip:

- Finish identifying all previously unknown organisms which you have collected and brought back using identification manuals listed in the reference section at the end of this book. Fill out species file cards completely, including an

- accurate sketch on the back of the card.
- Make a dichotomous key to the organisms you observed.
 - Research: What are some ways that beach animals are adapted to life under the harsh conditions discussed on page 48?

Task Five: Plankton

A. Before the field trip:

- research phytoplankton and zooplankton thoroughly.
- read about one-celled organisms and the structures normally found in their bodies.
- gather together the necessary materials to take on the trip. In particular, be sure you have the plankton net and a number of collecting jars.

B. At the study site:

Using the long-handled plankton net, make a number runs through the water. An alternative is to pour about thirty buckets full of sea water through the net. Each time you pull the net in, remove the bottle from the net, and empty its contents into a jar. The jars should be properly labeled. If you must wait at the site for any length of time, place your samples in the shade or the heat of the sun will kill the plankton.

C. After the field trip:

- In order to keep the plankton alive, the samples must be put in a large jar, diluted with filtered sea water, and gently aerated. This can be done with an aquarium pump and an airstone. Otherwise, the samples may be preserved with 3-5% formalin solution.
- Pour a small portion of plankton sample and pour it into a petri dish. Gently swirl to distribute.
- Observe with the dissecting microscope, scanning

the entire field.

- transfer samples from different levels to slides, cover with cover slips, and examine under low and high power of the compound microscope. You may also want to observe samples on depression slides or using the oil immersion lens. Try to identify (scientific name) each different type of micro-organism you find, using the references listed at the end of this book. Then make neat accurate drawings (see Appendix A) of each, and measure (BSCS - Green Version has excellent directions for measuring with a microscope). For each one-celled organism, try to identify, draw, and label various structures that you observe in the cell. The nucleus may be observed by staining with methyl green (this will kill the organism, however). If you are having trouble observing a fast-moving animal, there are a number of techniques for slowing them down (see Paul Brandwein, Sourcebook for the Biological Sciences, p. 111-112).
- write a brief report about marine plankton and attach your lab drawings.
- make a dichotomous key to the organisms you identified.
- discuss special adaptations plankton have for moving.
- how do the different groups of plankton you found fit into the food chains of marine organisms?

Task Six:

Abiotic Factors

A. Before the trip:

- gather necessary equipment and prepare necessary data sheets.

B. At each quadrat station on one transect:

(Note: you need only make the following measurements on one of the three transects. Extend the transect line down to the water's edge)

1. temperature - use a centigrade thermometer to measure the air temperature and sand temperature at two or three depths.
2. wind - measure the wind velocity and direction at different heights above the sand. There are directions for constructing an anemometer in Terrestrial Ecology, by Andrews.
3. available water - record the depth at which water is reached.
4. sand sample - using a coring device, take a sample of sand from each quadrat station. A simple corer may be made by removing both ends of a coffee can. The can is pushed into the sand until the top of the can is flush with the sand surface. Then the contents are removed with scoops and put directly into plastic bags, tied securely, and tagged with information about location of sample. Samples are to be brought back to the lab for analysis.

C. In the water:

1. temperature
2. oxygen content - use an oxygen test kit to measure the amount of dissolved oxygen in the water. You must be particularly careful not to jostle or splash your sample before you measure. Otherwise you will alter the oxygen content.
3. pH - use a pH test kit for these measurements. Use the library to find out what pH is and why the proper pH is important. What can change the pH of a body of water?
4. turbidity - measure light penetration using a secchi disc. There are excellent directions

for the use of a secchi disc on page 91 of The Natural History Guide, by Laun. Why do you think light penetration is important?

5. salinity - measure salinity (amount of dissolved salt) using an instrument called a refractometer or a hydrometer (your teacher can explain the proper use of these) at various sites and then calculate an average salinity for the water at your study site.

D. Record the date, the time of day, and the level of the tide at the time you conducted your investigation.

E. Back in the classroom/laboratory:

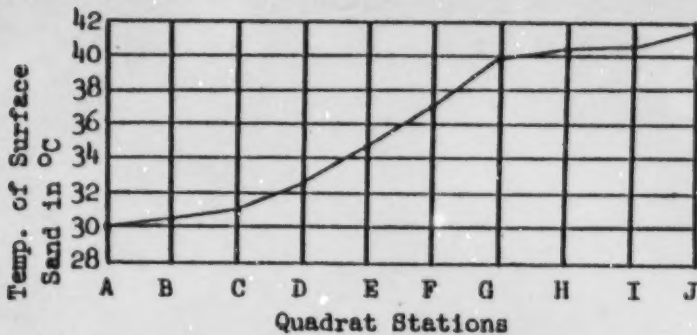
1. sand characteristics - because so many beach organisms spend most of their lives buried in the sand, there are certain characteristics of sand which are very important to their survival. Foremost among these are water-holding capacity, capillarity, amount of pore space and organic content. Consult A Guide to the Study of Soil Ecology, by W. A. Andrews, for the significance of these factors, and follow the procedures outlined in the book for investigating them. Perform the investigations upon each quadrat sample. Write up your results in a report and show in graph form how each factor changes as you move upward on the beach from water level to dune line.
2. particle sizing - the size of sand particles on a beach affects the slope of the beach, the water-holding capacity of the sand (or capillarity), the pore space, and consequently, the types of organisms which can live there. Appendix E gives directions for determining the percent of each particle size in a given sample of sand. Follow these directions to

investigate particle size for each quadrat sample. Make a chart showing your results, as shown below:

Percentage of each Particle Size in Sample	
Quadrat:	Sieve size: 5 7 10 32 80 250 325
A	
B	
C	
D	
E	
F	
G	
etc.	

Write a short essay explaining any change in percentage of each particle size as you move from water level to dune line. This will be an interpretation of your chart.

3. Plot graphs of the temperature, wind velocity, and available water at each quadrat station. Plot the environmental factor on the vertical axis and the quadrat stations on the horizontal axis. This makes it easy to spot any relationships between environmental conditions and plant populations. An example of such a graph is given on the next page.



4. Try to relate your findings in #1, #2, and #3 above to the pattern you found in animal and plant life as you moved up the beach.

Task Seven: Microscopic Forms in the Sand

At the study site, remove an area of sand at the low tide line approximately 2 cm deep and 30 cm square. Place the sample in a container and return it to the lab.

Once back in the laboratory, follow the directions found on pages 47 - 51 of Sourcebook of Marine Sciences, for "Investigating Microscopic Forms in the Sand". Display your results as the book suggests and answer the five questions on page 49.

Task Eight: Food Webs

Draw one possible food web found in a beach ecosystem, using the organisms you collected or identified.

Task Nine: Man

Research the importance or impact that man has on the beach and salt-water (marine) ecosys-

tems in general. Why are these ecosystems important to him, what is he doing to destroy them, and what is he now doing to prevent this destruction?

THE STUDENT BOOKLET SUGGESTED FORMAT

Remember that your primary goal in this exercise was to put together a booklet describing an accurate in-depth study of a pond, lake, river, or beach ecosystem. Now that you have completed the field and lab study portion and have researched your topic thoroughly, it is time to compile your group's data and put together a finished product. The most accurate and complete booklets will be bound, catalogued and placed in the school library for everyone's use. Although you may use your own ideas for the format of your booklet, one possible approach is outlined below:

COVER AND TITLE PAGE

I. TABLE OF CONTENTS

II. INTRODUCTION

III. INFORMATIVE TEXT: This section includes library information pertaining to fresh-water or marine ecosystems. Its purpose is to give the reader some basic background knowledge of what is known to be true of this particular type of ecosystem. This section should be proofread and corrected for grammatical and spelling errors. Use the information gathered in the research portions of Parts Three and Four of this book.

IV. YOUR GROUP STUDY

A. A Brief Summary of the Purpose of the Study

B. Description of Site Location (possibly including a map and graph of slope)

C. Equipment/Materials List

D. Analysis of Vegetation

1. Qualitative-descriptions and drawings

- 2. Quantitative-show your graphs
- E. Animal Life - description (include drawings where possible)
- F. Plankton
- G. Abiotic Factors - graphs
- V. Typical Food Web of your ecosystem
- VI. Impact of Man upon this aquatic ecosystem.
Discuss the importance of this ecosystem to man and its place in the biosphere. Why must it be protected?
- VII. Appendix
Dichotomous keys
Description of any special methods or equipment constructed
- VIII. Bibliography - should be complete and accurate

APPENDIX A

LAB DRAWINGS

(From: Tracy I. Storer and Robert L. Usinger.
Laboratory Manual for Zoology. New York: McGraw-Hill Book Company, 1958.)

The making of original drawings requires careful attention to details, hence is helpful in learning, and is also training in the preparation of scientific records. When graded by the instructor, drawings are rated on accuracy and completeness rather than on artistic merit, since the ability to draw varies widely among students. Copies of text illustrations as substitutes for original drawings are recognized readily by the instructor ---and may be rated as cheating...

In making laboratory drawings, give attention to the following:

1. First observe and study the laboratory material as carefully as possible; then draw what is seen.
2. Draw directly from the specimens or slides, and complete all figures in the laboratory.
3. Arrange the figures on a sheet in a symmetrical pattern.
4. Make each figure large enough to show all details clearly. It should be simple and clear, mainly in outline, and necessarily somewhat diagrammatic.
5. Extensive repetition of repeated parts is unnecessary; instead, show a few with careful detail.
6. Use a sharp hard pencil (3H, 4H); avoid sketchy lines and soft or blunt pencils; do not ink or shade unless directed to do so. [An effective neat way to shade where necessary is to stipple, i.e., to fill in the space with tiny pencil dots placed close together.]

7. First mark out lightly the extreme length and width (or diameter) to be occupied by a figure. If the specimen is bilaterally symmetrical, draw a faint longitudinal axis as a temporary guide in the placement of parts. Then outline the figure lightly. Estimate the proportionate size of some component parts in relation to the entire specimen, and mark these on the area outlined for the drawing. Draw the major features, fill in the details, and strengthen lines where necessary. Finally erase any unneeded marks.
8. Leave space, preferably at the right of the figure, for the labels. Label every part of each figure...Rule a fine line from each part horizontally to its label, and print or write each label neatly. Do not cross the lead lines.
9. For parts not seen in a specimen, consult any demonstration material and add the missing parts to the figure; otherwise note the part as "not seen" on the drawing.
10. Under each individual drawing give the figure number, title, and the approximate scale of reduction or enlargement as compared with the specimen, thus:

The Frog. Circulatory System, ventral
view X 2.

APPENDIX B

KILLING INSECTS

(From: Interaction Science Curriculum Project.
Interaction of Man and the Biosphere. Chicago:
Rand-McNally and Company, 1970.)

Once an insect has been captured, it must be put into a killing jar so it may be handled and prepared for study. The safest jar is one that contains carbon tetrachloride as a killing agent. Carbon tetrachloride is a cheap, nonflammable substance that can be purchased at drugstores. Avoid breathing carbon tetrachloride fumes - they are poisonous.

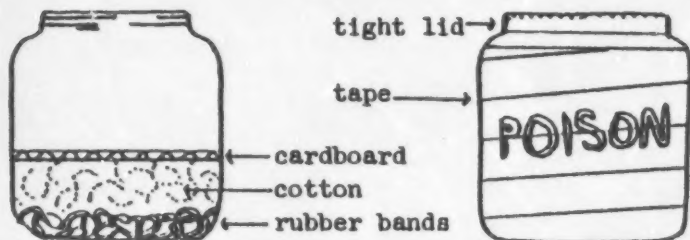
Materials (for one killing jar):

$\frac{1}{2}$ pt. jar (peanut butter, etc.)
rubber bands
carbon tetrachloride
absorbent cotton
heavy cardboard, cut to fit into the jar
jar lid
masking or adhesive tape

Procedures

- A. Pack some rubber bands into the bottom of the jar.
- B. Soak the rubber bands in carbon tetrachloride. After soaking, pour off the excess, if any.
- C. Place absorbent cotton over the rubber bands. Then cut a piece or two of heavy cardboard that can be put over the cotton. Punch a few holes in the cardboard to allow the fumes to come up from the rubber bands.
- D. It is a good idea to wrap the bottom of the jar

in masking tape or adhesive tape so the contents will not be scattered if the jar is broken.



- E. Label the jar POISON so other people are aware of the danger. Make sure the jar is tightly covered when not in use. Since fumes will escape, the carbon tetrachloride may have to be replaced from time to time.

The length of time that an insect has to remain in the jar before dying will depend on its size and type. Most flying insects will die very soon, but large crawling insect might have to stay in the jar several minutes. Carbon tetrachloride will dry out insects very quickly, so it is a good idea to prepare your insects soon after taking them out of the killing jar.

APPENDIX C

MEASURING SLOPE

(From: Outdoor Biology Instructional Strategies.
"Terrestrial Hi-LO Hunt". University of California,
April, 1974.)

Materials:

- | | |
|-------------------|--------------------|
| 1 meter stick | 1 level tube (test |
| 1 125 cm piece of | tube - no lip) |
| strong cord | 1 cork to fit tube |
| 1 25 cm sharpened | detergent |
| stick | water |
| | clear tape |

Slope can be determined by fixing an anchor at the upper part of the slope, drawing the one meter cord taut, sliding it up or down until the cord is level, and reading slope directly in cm/meters. Assemble the apparatus like this:

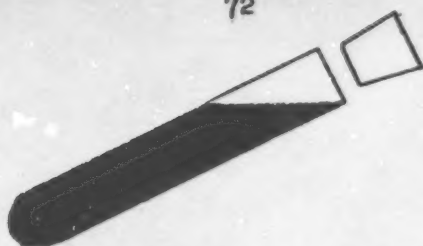
1. Sharpen the 25 cm stick and fasten the cord to it securely.



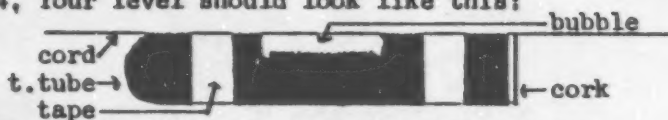
2. Attach the free end of the cord to the meter stick so that the distance between the two sticks is one meter, and the cord can slide on the meter stick.



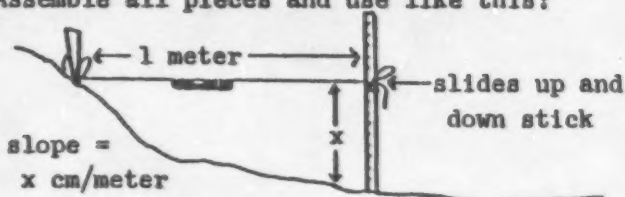
3. Make your level. Fill the test tube almost full of water with a bit of detergent (1 cc/liter). Cork the tube so that a small bubble remains. Trim off the top of the cork.



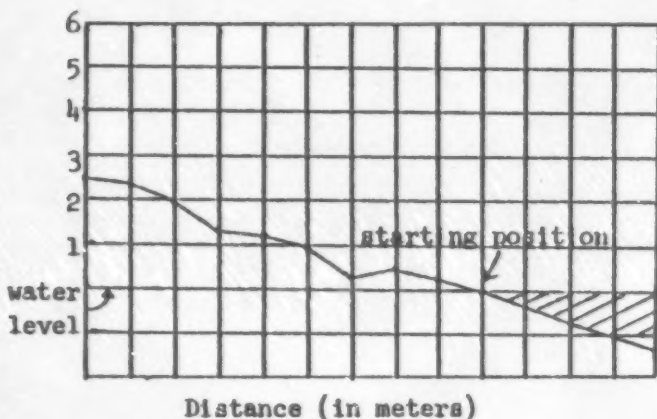
4. Your level should look like this:



5. Assemble all pieces and use like this:



6. Plot your measurements on a piece of graph paper, like so:



APPENDIX D

COLLECTING ORGANISMS FOR IDENTIFICATION PURPOSES

(From: Berger, Neal H. "Environmental Management Study Area". Florida Department Of Education, Office of Environmental Education Minigrant, 1974-75.)

1. If an organism can be identified outdoors (in the field), without injury or death, by all means do so.
2. Small parts of most plants can be removed for identification purposes without injuring the plant.
3. Remove (typical) average leaves from plants and enough of the stem to see the leaf arrangement.
4. Flowers, fruits and other structures besides leaves are helpful aids to identification.
5. Knowing the type of plant an insect is found on may help identify it.
6. Return organisms alive, if possible, to your study plots when identified.
7. Keep a written record of where animals are caught or seen.
8. Animals don't have to be seen to be identified. Sound, smell, touch, and signs left by the animals are helpful hints.
9. Search very carefully. Many animals are camouflaged or very small.

APPENDIX E

SAND PARTICLE SIZING

(From: "Sourcebook of Marine Sciences," NDEA Special Project, Florida State Department of Education, 1968, p. 25-26.)

Arrange the individual sieves in a nest such that those with the largest sieve opening are at the top. Each sieve in the set has a smaller opening than the one above. Finally there is a bottom pan and a cover. A typical sieve set comprises 5 or 6 sieves. NBS (National Bureau of Standards) sizes used for selection are 5, 7, 10, 35, 80, 250, and 325.

- A. 1. Scoop dried sample onto the top sieve. 2. When the pile of material indicates that the sieve is blocked put on the top; rock the nested sieves to-and-fro. Allow the bottom to "bump" on each movement. Allow the whole stack of sieves to turn in the hand after each oscillation. 3. Periodically add more material to the top sieve until all of the sample has been graded for size. If one or more sieves or the bottom pan fills with material, this can be emptied into a bag(s) or container(s). The stack of sieves can be reassembled for continued operations.
- B. Sample Removal and appraisal: 1. Remove cover. 2. Agitate the top sieve so as to cause the sub-sized material retained on this sieve to pass through the openings. Stirring with the handle of the brush will help to cause these particles to pass through. 3. Empty the contents retained on the top sieve into a separate container of known mass. 4. Determine mass of container plus sample fraction. Subtract mass of container.

5. The percent (%) is found by dividing the mass of fraction by mass of whole dry sample. Repeat steps 1-5 above for each succeeding sieve. Brush the lost particles into the container.

FOOTNOTES

¹Biological Sciences Curriculum Study, Biological Science: An Environmental Approach - Teacher's Edition, 3rd ed. (New York: Rand-McNally and Company, 1973), p. T231.

²Ibid., p. T1.

³Ibid.

⁴Ibid., p. T231.

⁵Youth Conservation Corps Sourcebook for Environmental Awareness, "People and Natural Resources" (Summer, 1977), p. 5.

⁶Biological Sciences Curriculum Study, Biological Science: An Environmental Approach, 3rd ed. (New York: Rand-McNally and Company, 1973).

⁷Ibid., p. 200.

⁸R.L. Smith, Ecology and Field Biology, 2nd ed. (New York: Harper & Row, Publishers, 1974) p. 6.

⁹Interaction Science Curriculum Project, Interaction of Man and the Biosphere (Chicago: Rand-McNally and Company, 1970) p. 182.

¹⁰Gail Nichols et al, "Florida's Wildlife" (Florida Department of Education, Office of Environmental Education, 1975) p. 54.

¹¹Smith, p. 26.

¹²"Student-Teacher Environmental Relationships Investigation - The Salt Marsh, Student Packet" (ESEA - Title III, Board of Public Education for the city of Savannah, Georgia, 1974-75) p. 8-9.

¹³Biological Science Curriculum Study, p. 278.

¹⁴Smith, p. 592.

¹⁵Joseph J. Shomon, "The Dramatic World of the Seashore", Audubon Nature Bulletin, Series 32, No. 2.

¹⁶Environmental Studies Center, Gulf Island National Seashore, "Santa Rosa Island Beaches" (Florida Department of Education, Office of Environmental Education), p. B-1

¹⁷An excellent section on preserving marine organisms can be found in Seashore Life, by Gilbert Voss (see Reference List).

REFERENCES
AND AIDS TO IDENTIFICATION

General

- Andrew, William A., ed. Soil Ecology. Englewood, New Jersey: Prentice-Hall, Inc., 1973.
- Andrew, William A., ed. Terrestrial Ecology. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1974.
- Biological Science Curriculum Study. Biological Science: An Environmental Approach. 3rd ed. New York: Rand-McNally & Company, 1973.
- Brandwein, Paul; Joseph, Alexander; and Morholt, Evelyn. Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, Inc., 1966.
- Enger, Gibson, Kormelink, Ross, and Smith. Concepts in Biology. Dubuque, Iowa: Wm. C. Brown Company, 1976.
- Green, Edna and Smallwood, William. Biology. Morristown, New Jersey: Silver-Burdett Company, 1968.
- Otto, James and Towle, Albert. Modern Biology. New York: Holt, Rhinehart & Winston, Inc., 1963.
- Smith, R. L. Ecology and Field Biology. 2nd ed. New York: Harper and Row, Publishers, 1974.
- Wigginton, Elliot, ed. The Foxfire Book. Garden City, New York: Anchor Press/Doubleday, 1972.

General - Rivers, Lakes, and Ponds

- Abraham, Norman; Beidleman, R.G.; Moore, John A.; Moores, Michael; Utley, William J. Interaction of Man and the Biosphere. Chicago: Rand-McNally & Company, 1970.
- Amos, W.H. "Teeming Life of a Pond." National Geo-

- graphic Magazine, June, 1965, p. 274-298.
- Amos, W.H. "Unseen Life of a Mountain Stream." National Geographic Magazine, April, 1977, Biological Science Curriculum Study. Biological Science: An Environmental Approach. 3rd ed. New York: Rand-McNally & Company, 1973.
- Coker, Robert E. Streams, Lakes and Ponds. Chapel Hill: University of North Carolina Press, 1954.
- Laun, H. Charles. The Natural History Guide. Alton, Illinois: Alsace Books and Films, 1967.
- Needham, James G. and Paul R. Guide to the Study of Fresh-Water Biology. San Francisco: Holder-Day, Inc., 1962.
- Reid, George K. Pond Life. New York: Golden Press, 1967.
- Smith, H.G. Tracking the Unearthly Creatures of Marsh and Pond. Nashville: Abington Press, 1972.
- Thurber, Walter A. and Kilburn, Robert E. Exploring Life Science. Boston: Allyn and Bacon, Inc. 1966.

General - Beach

- Amos, W. H. "The Living Sand." National Geographic Magazine, June, 1965, pp. 820-833.
- Anikouchine, William A. and Steinberg, Richard W. The World Ocean. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1973.
- Biological Science Curriculum Study. Biological Science: An Environmental Approach. 3rd ed. New York: Rand-McNally and Company, 1973.
- Carson, Rachel. The Edge of the Sea. Boston: Houghton-Mifflin Company, 1955.
- Coker, R.E. This Great and Wide Sea. New York: Harper & Row, Publishers, 1962.
- Gross, M. Grant. Oceanography, A View of the Earth. Englewood, NJ: Prentice-Hall, Inc., 1972.

- Gulf Specimen Company, Inc. Catalog #5. Panacea, Fla: Gulf Specimen Company, 1975.
- Hylander, C. J. Sea and Shore. New York: Mac-Millan Company, 1966.
- Morton, J. E. Molluscs. London: Hutchinson & Company, Ltd., 1967.
- Rabinowitz, Abraham; Sutton, T. B.; Taylor, E. M. Oceanography: An Environmental Approach to Marine Science. Lodi, N.J.: Oceanography Unlimited, Inc., 1970.
- Ranwell, D. S. Ecology of Salt Marshes and Sand Dunes. London: Chapman & Hall, 1972.
- Rudloe, Jack. The Erotic Ocean.
- Rudloe, Jack. The Living Dock at Panacea. New York: Alfred A. Knopf, 1977.
- Rudloe, Jack. The Sea Brings Forth. New York: Alfred A. Knopf, 1968.
- Scientific American. The Ocean. San Francisco: W. H. Freeman & Company, 1969.
- Scientific American. Oceanography. San Francisco: W. H. Freeman & Company, 1971.
- "Sourcebook of Marine Sciences." NDEA Special Project, Florida State Department of Education, 1968.
- Voss, Gilbert L. Seashore Life. Miami, Fla.: E. A. Seeman Publishing Company, Inc., 1976.
- Weyl, Peter K. Oceanography. New York: John Wiley & Sons, Inc., 1970.

Plants

- Baker, Mary Francis. Florida Wildflowers. New York: The MacMillan Company, 1938.
- Biological Science Curriculum Study. Biological Science: An Environmental Approach. 3rd ed. New York: Rand-McNally & Company, 1973.
- Cobb, Boughton. Field Guide to the Ferns. Boston: Houghton-Mifflin Company, 1963.

- Conard, Henry S. How to Know the Mosses and Liverworts. Dubuque, Iowa: Wm. C. Brown Co., 1956.
- Dawson, E. Yale. How to Know the Seaweeds. Dubuque, Iowa: Wm. C. Brown Company, 1956.
- Dawson, E. Yale. Marine Botany. New York: Holt, Rhinehart & Winston, Inc., 1966.
- Duncan, Wilbur H. and Foote, Leonard E. Wildflowers of the Southeastern United States. Athens: University of Georgia Press, 1975.
- Gulf Specimen Company, Inc. Catalog #5. Panacea: Gulf Specimen Company, 1975.
- Laun, H. Charles. The Natural History Guide. Alton, Illinois: Alsace Books and Films, 1967.
- Martin, Alexander C. Weeds. New York: Golden Press, 1975.
- Peterson, Roger Tory and McKenny, Margaret. Field Guide to Wildflowers. Boston: Houghton-Mifflin Company, 1968.
- Petrides, George A. Field Guide to Trees and Shrubs. Boston: Houghton-Mifflin Company, 1972.
- Prescott, G. W. The Algae: A Review. Boston: Houghton-Mifflin Company, 1968.
- Prescott, G. W. How to Know the Fresh-Water Algae. Dubuque, Iowa: Wm. C. Brown Company, 19--.
- Reid, George K. Pond Life. New York: Golden Press, 1967.
- Smith, Alexander H. Mushroom Hunters Field Guide. Ann Arbor: The University of Michigan Press, 1974.
- Stodola, J. Encyclopedia of Water Plants. Hong Kong: T.F.H. Publications, Inc., Ltd., 1967.
- Taylor, Kathryn S. and Hamtlin, Stephen F. Handbook of Wildflower Cultivation. London: Collier MacMillan Publishers, 1963.
- Venning, Frank D. Cacti. New York: Golden Press, 1974.

Animals

- Abbott, R. Tucker. Seashells of the World. New York: Golden Press, 1962.
- Biological Science Curriculum Study. Biological Science: An Environmental Approach. 3rd ed. New York: Rand-McNally & Company, 1973.
- Borror, Donald J. and White, Richard E. A Field Guide to Insects. Boston: Houghton-Mifflin Company, 1970.
- Breder, Charles M., Jr. Field Book of Marine Fishes. New York: G. R. Putnam's Sons, 1948.
- Bruun, Bertel; Robbins, Chandler S.; and Zim, Herbert S. Birds of North America. New York: Golden Press, 1966.
- Buchsbaum, Ralph. Animals without Backbones. Chicago: University of Chicago Press, 1970.
- Burt, William H. and Grossenheider, Richard P. A Field Guide to Mammals. Boston: Houghton-Mifflin Company, 1976.
- Carson, Rachel. The Edge of the Sea. Boston: Houghton-Mifflin Company, 1955.
- Eddy, Samuel. How to Know the Freshwater Fishes. Dubuque, Iowa: Wm. C. Brown Company, 1957.
- Hegner, Robert W. An Introduction to Zoology. New York: MacMillan Company, 1924.
- Hochbaun, H. Albert. Travels and Traditions of Waterfowl. Minneapolis: University of Minnesota Press, 1956.
- Hylander, C. J. Insects on Parade. New York: MacMillan Company, 1968.
- Jenkins, Marie M. The Curious Molluscs. New York: Holiday House, 1972.
- Klots, Alexander B. A Field Guide to Butterflies. Boston: Houghton-Mifflin Company, 1975.
- Laun, H. Charles. The Natural History Guide. Alton, Illinois: Alsace Books and Films, 1967.
- Minton, Madge R. and Sherman A., Jr. Venomous

- Reptiles. New York: Charles Scribner's Sons, 1969.
- Morton, J. E. Molluscs. London: Hutchinson & Company, Ltd., 1967.
- Murie, Olaus J. Field Guide to Animal Tracks. Boston: Houghton-Mifflin Company, 1975.
- Ommanney, F. D. The Fishes. New York: Time-Life Books, 1970.
- Perlmutter, Alfred. Guide to Marine Fishes. New York: New York University Press, 1961.
- Zepe, Clifford H. Snakes Alive. New York: Viking Press, 1962.
- Rudloe, Jack. The Erotic Ocean.
- Rudloe, Jack. The Living Dock at Panacea. New York: Alfred A. Knopf, 1977.
- Rudloe, Jack. The Sea Brings Forth. New York: Alfred A. Knopf, 1968.
- Storer, Tracy I. and Usinger, Robert L. Laboratory Manual for Zoology. New York: McGraw-Hill Book Company, 1958.
- Swain, Ralph B. The Insect Guide. New York: Doubleday & Company, 1948.
- Voss, Gilbert G. Seashore Life. Miami, Fla.: E. A. Seeman Publishing, Inc., 1976.
- Zarchy, Harry. Let's Fish. New York: Alfred A. Knopf, 1952.
- Zim, Herbert, Ph.D. and Smith, Hobart M. Reptiles and Amphibians. New York: Golden Press, 1956.

Microorganisms

- Biological Science Curriculum Study. Biological Science: An Environmental Approach. 3rd ed. New York: Rand-McNally & Company, 1973.
- Davis. Marine and Freshwater Plankton. Chicago: Michigan State University Press, 1955.

- Laun, H. Charles. The Natural History Guide.
Alton, Illinois: Alsace Books & Films, 1967.
- Prescott, G. W. The Algae: A Review. Boston-
Houghton-Mifflin Company, 1968.
- Prescott, G. W. How to Know the Fresh-Water Algae.
Dubuque, Iowa: Wm. C. Brown Company, --
- Reid, George K. Pond Life. New York: Golden Press,
1967.
- "Sourcebook of Marine Sciences." NDEA Special
Project, Florida State Department of Educa-
tion, 1968.

Audiovisual Aids

Kits:

- Ecology: Interrelationships in Nature. Chicago:
Society for Visual Education, 1974.
- Modern Biology: Environmental Survival.
Chicago: Society for Visual Education, -
- Sea Life. Washington, D.C.: National Geographic
Society, 1973.
- Understanding Oceanography. Chicago: Society
for Visual Education, 1966.

Filmloops:

- Animal Plankton. Encyclopedia Britannica
Educational Corporation.
- Recognizing Plankton. Encyclopedia Britannica
Educational Corporation.
- Sandy Ocean Shore. Encyclopedia Britannica
Educational Corporation.